ARO 27574.6-MA

AD-A253 521

HISTORY OF STATISTICS IN REAL TIME: HAMMERS AND NAILS

Technical Report # 170

May 1992

DTIC
ELECTE
AUG 0 3 1992
S B D

Emanuel Parzen

Texas A&M Research Foundation

Project No. 5641

Sponsored by the U. S. Army Research Office

Professor Emanuel Parzen, Principal Investigator

Approved for public release; distribution unlimited

92-20878

92 7 31 163

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to Washington Headquarters Services, Directorate for information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	May 1992	

4. TITLE AND SUBTITLE
HISTORY OF STATISTICS IN REAL TIME: HAMMERS AND NAILS

5. FUNDING NUMBERS
DAAL03-90-G-0069

6. AUTHOR(S)
EMANUEL PARZEN

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Texas A&M University
Department of Statistics
College Station, TX 77843-3143

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U. S. Army Research Office
P. O. Box 12211
Research Triangle Park, NC 27709-2211

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
ARO 27574.6-MA

11. SUPPLEMENTARY NOTES
The view, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other documentation.

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

1. Is what statisticians do fun?
2. Statistical hammers and nails can help guide what statisticians do.
3. Hammers that make statisticians dull.
4. History of Statistics in Real Time and Stigler's Book.
5. Esoteric research should provide exoteric hammers.
6. Quality control of the art of statistical science.

14. SUBJECT TERMS
Statistical computation, computational statistics, exoteric research, esoteric research, history of statistics, quality of the art of statistical science.

15. NUMBER OF PAGES
8

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UL

History of Statistics in Real Time: Hammers and Nails

After Dinner Talk
by
Emanuel Parzen
Department of Statistics
Texas A&M University, College Station, TX 77843

Contents

1. Is what statisticians do fun?
2. Statistical hammers and nails can help guide what statisticians do.
3. Hammers that make statisticians dull.
4. History of Statistics in Real Time and Stigler's Book
5. Esoteric research should provide exoteric hammers.
6. Quality control of the art of statistical science.

1. Is what statisticians do fun?

What statisticians do is even analyzed in comic strips! I quote "Miss Peach: Arthur's Career Advice".

Question: "Arthur, I'd like to become a statistician. What are my chances?"

Answer: "If you don't know, you've made the wrong choice."

A statistical tradition is that a statistical talk should begin with a joke. I can tell many jokes of the form: "How many statisticians does it take to change a light bulb?" One answer: "Can we get back to you on that; our computers are working it out."

But instead of telling you a cryptic joke, I would like to begin my talk just as cryptically by telling you the proverb which motivates my title.

"To the statistician with a hammer, every problem is a nail."

My talk will propose a revised proverb:

"The statistician needs a unified set of classical and modern hammers, so that almost every problem can be transformed to a nail. The statistician needs nails, so that the hammers can be fun (functional and fundamental). The computational statistician needs graphs which are fun in the sense that they represent plots of functions."

Let me note that the Box Plot introduced by Tukey may not be fun (a representation of a function). I propose a Density Quantile Box Plot.

An after dinner talk traditionally should make people laugh. After all, it should be a fun talk.

Short run fun is provided by the stand up comic approach about statistical personalities. (I could tell you a story about a Fellow *Texan* or a *Fellow* Texan).

Among performers who make people laugh one can distinguish comedians, comics, and humorists. A comedian says *funny things*. A comic says *things funny*. A humorist *delivers a message*. All tailor their material to fit their audiences. Let me adapt a story told by humorists.

In my story the cast is computational statisticians from Texas, the San Francisco Bay Area, New Jersey, and New England who met tonight before dinner at the drinking hour.

My life has been interesting because I have lived on all four American coasts (East, West, Great Lakes, and Gulf), have Mathematics degrees from Harvard and Berkeley, been a Statistics Department faculty member for many years at a diversity of universities (Columbia, Stanford, SUNY Buffalo, and Texas A&M), and visited widely (geographically and intellectually).

The Texas computational statistician poses as a fisherman. He says to the West Coast statistician: "You should have been with me last night. I caught a 65 pound catfish." They are joined by the New Jersey statistician, and the Texan tells him: "I caught a 35 pound catfish last night." When the statistician from New England joins them, the Texan tells him: "You should have been fishing with me last night. I caught a 25 pound cat." The Californian exclaims: "That fish of yours is kind of shrinking, isn't it." The Texan explains: "I learned a long time ago that you never tell a man more than you think he'll believe."

As an example of how art stimulates life, let me note how I am stimulated by the reverse word order definitions of a comedian (funny things) and comic (things funny) to conjecture reverse word order definitions of statistical computation (computation of statistics) and computational statistics (statistics from computation). "Statistical computation" uses computing science to conveniently compute statistics, while "computational

statistics" creates new (often, computer intensive) statistics made possible by advances in computers, computer science and signal processing.

2. Statistical hammers and nails can help guide what statisticians do.

My approach in my after dinner talk is to seek long run fun by preaching "fun statistics". My goal is to offer you the equivalent of a *fortune cookie* which clearly is appropriate as after dinner fun.

The good fortune that I would like to offer you tonight is one that I believe statisticians would like to have at their side as they take the many "Oral Exams" that a statistician encounters in a long career. These exams occur during the statistician's interactions with clients with whom one is collaborating or with whom one is counseling on how to apply statistical methods.

Your fortune cookie of the night reads:

"You have good friends who will come to your aid in time of need."

Tonight I would like to introduce a good friend which may be able to provide guidance to the past and future (real time) practice of statistics. This friend is your appreciation of the history of statistics and classifying what happened in the past (and what ought to happen in the future) as being either new hammers or new nails.

Hammers are instruments or tools or "statistical datascopes" analogous to telescopes and microscopes. *Nails* are the applied phenomena and data that we research with these instruments, tools, or scopes.

When one proposes a symposium to a funding agency, they demand a justification; "what's new to discuss?" they ask. The answer can be either "new theory and methods (new hammers)" or "new applications and data (new nails)".

Early in my career in my interaction with electrical engineers I would try to clarify our relationship: "Why is it if I know something, you call it 'theory' while if you know it you call it 'applied'?" I would explain this situation today by saying that something known to the statistician is usually a hammer, and something known to the applied researcher is usually a nail.

It should be noted that there are several levels of being a hammer (theoretical) and a nail (application). There is an exciting new field of approximation theory called "wavelet theory". It is a mathematical hammer developed by applied mathematical scientists to represent and approximate a function defined abstractly. It is a mathematical nail and simultaneously a statistical hammer when used by statisticians; my personal research goal is to develop nails which are statistically meaningful functions (such as the comparison density or change density) to estimate (often using wavelet or kernel estimators). Another statistical nail (for the hammer of wavelet estimation) is dependence density functions that disclose or expose the regions where two variables X and Y have a positive association.

In 1955 I was starting to do research on the foundations of modern time series analysis (spectral analysis, extraction of signals from noise). To my statistical colleagues I said in jest "After all, regression analysis is the discrete parameter analogue of continuous parameter time series analysis". I strongly recommend that in 1992 this jest should be taken seriously; as we study wavelet theory (and reproducing kernel Hilbert spaces) we should ask what are the analogues in regression analysis.

3. Hammers that make statisticians dull.

One problem that statisticians traditionally seem to have is that they may have overdeveloped the art of insulting each other's work. Henry Mann (a mathematician who spent his mid-career in statistics) said to me in 1967 after a talk I had just given:

"That's why I left statistics. Instead of discussing what you did, they discussed why you should not have done it."

If one does theory, the reaction one usually gets to one's work is a three pronged attack:

- "It won't work."
- "If it works, it's not new."
- "If it's new, it's trivial."

If one does applied work, typical of our colleagues' attacks is the attitude expressed in the proverb that I quoted at the beginning of my talk:

"To the statistician with a hammer, every problem is a nail."

One interpretation of this criticism is one often expressed by dissatisfied clients of a statistician (denoted S). "S hardly listened to my problem (nail), before assuring me he had the solution (hammer) already available in his tool kit." The motto of a statistician who works as a consultant is equivalent to: "have hammer, will travel."

This criticism compares statisticians to Procrustes, the mythical inn keeper, who had one bed in his inn which he transformed all travelers to fit; his motto was "one bed fits all".

I mention the Procustes criticism because I believe it illustrates the main point of my talk which is that to understand the many influences that have contributed to the past history of modern statistics, and can guide

the development of its future history, we should think of new developments as being of two types which we can call hammers and nails. If we think this way then we might conclude that graduate education in statistics is dull because it has too much recipe theory and recipe methods!

I believe that computational statisticians are more ready to implement education in "adaptive theory" which integrates theory and methods and makes it easier to adapt theory to new problems and thus have the ability (on the occasions when it is needed) to provide each nail (client) with custom made hammers (rather than off the shelf hammers) adapted for realistic probability models for the client's nails.

4. History of Statistics in Real Time and Stigler's Book

The history of statistics is being increasingly fashionable to study. Important and exciting books are

Todhunter. (1865). *A History of the Mathematical Theory of Probability from the Time of Pascal to that of Laplace.*

David, F. N. (1962). *Games, Gods and Gambling.*

Hacking, Ian (1975). *The Emergence of Probability*

Stigler, Stephen (1986). *The History of Statistics: the Measurement of Uncertainty before 1900.*

Porter, T. M. (1986). *The Rise of Statistical Thinking: 1820-1900.*

Edwards, A. W. F. (1987). *Pascal's Arithmetical Triangle.*

Daston, Lorraine (1988). *Classical Probability in the Enlightenment.*

Hald, A. (1990). *A History of Probability and Statistics and Their Applications before 1750.*

About the history (in real time) of computational statistics we are fortunate to have available two important and marvelous books:

Tufte, Edward (1983) *The Visual Display of Quantitative Information*

Tufte, Edward (1990) *Envisioning Information.*

What I would like you to remember from my talk is my concept of "history of statistics in real time" which proposes that we should study history from the point of view of how it guides us in our current practice of the discipline and profession of statistics, and to accomplish this the history of statistics should be appreciated as the history of hammers and nails.

I believe that evidence for my proposition can be provided by quoting the last 3 pages (pp. 358–361) of Steve Stigler's impressive 1986 book (*The History of Statistics: The Measurement of Uncertainty before 1900*). My interpretation of Stigler's summary: during the period 1750–1900 in which statistics developed into a science, there was one hammer (it was least squares all the way) and a progression of nails (the fields of application of the developing science of statistics changed over many fields from astronomy to social sciences to genetics).

> Yule's work provides a symmetric ending to this narrative: We began this history with the method of least squares and we shall end with the method of least squares. Yet the story is far from being circular. Over a two-century period there had been sporadic progress in the measurement of uncertainty, a sequence of developments we may think of as leading toward a completion of the logic of the quantification of science, by eventually permitting the formal evaluation and comparison of measurements. In this sequence the early achievements in astronomy and geodesy were in some respects like the later successes in the social sciences. In both cases a key barrier had been the lack of a conceptual structure that permitted the combination of observations; and in both cases the theory of probability had played a crucial role in overcoming the barrier, with the method of least squares supplying the means for completing the calculations. Beyond these broad similarities, however, lay a number of important differences.
>
> In astronomy the combination of observations had required both the anchor of the mathematical theory of gravitation and the growing knowledge of the behavior of random sums. The theoretical structures of celestial mechanics not ony defined the goals for the astronomers' empirical work but also helped the astronomers to reach those goals. By giving a link between different measurements of the same body, Newtonian theory provided a route by which the measurements could be combined, a way in which the relatively small numbers of major causes could be incorporated in one equation and related to the observations. Yet, as the example of Euler shows, that link was not enough by itself. A theory of errors was also needed, both the idea that combining measurements was beneficial, not harmful, and a means for turning the combination to inferential use.

Mayer grasped this intuitively in 1750 and a few years later Simpson added a formal analysis for simple means, but it took over a half-century before the grand Gauss–Laplace synthesis of 1810 was achieved. The delay is ample testimony to the difficulties of formulating, much less solving, the problem. Nevertheless, by the time of Laplace's death in 1827 a major success had been recorded, and the use of probability to measure, compare, and interpret uncertainty was well on the way to becoming a commonplace in astronomy and geodesy.

In the social sciences the problem took on a different face. It was not that theory was lacking: By the middle of the nineteenth century several economists had given mathematical expression to the theories of Adam Smith and David Ricardo. But even though these theories might have captured the major causes that were of interest to the economist, they did not incorporate the myriad causes of little concern in economic theory that nonetheless had a major impact upon the data used to test that theory. Cournot could relate price and demand in theory, all other things being held constant, but he could not hold all other things constant in the real world. A new conceptual approach was needed, and it arose from an unexpected quarter–from studies of heredity.

Galton, Edgeworth, and Pearson assembled the structure; Yule completed it by finding a variation on their advances that finally provided a formulation and analysis for questions in the social sciences. It is ironic that in some respects the tool Yule used was an old tool, the method of least squares. Of course, the matter was much subtler than that; it was not Legendre's or even Gauss's or Laplace's least squares that Yule found, but a superficially similar tool that had transformed by the concepts developed by Galton and others. Legendre's least squares had been around and freely available for ninety-five years. But when it had been tried before, in isolated instances, it had not answered the right questions. By 1900, though, the questions could be reformulated so that the astronomer's least squares could be used to new purpose. It was not merely an elegant variation of language that called for the term *regression analysis* for this conceptually new use of least squares. In 1805 the coefficients were constants, deriving their meaning from an exterior theory. In 1900 the coefficients were interior theoretical constructs, given their meaning in the context of Galton's variance component models as what we now characterize as conditional expectations of multivariate distributions. In this new framework least squares provided the homogeneous subclassifications for analysis Quetelet had sought while offering a sufficiently restricted setting that Cournot's worries about post-data selection could be addressed in at least limited ways.

The realization that the regression and correlation concepts that had emerged in Galton's studies of heredity were intimately related to the least squares of the beginning of that century was the second great synthesis of the history of statistics. In this second synthesis, probability had played a role rather different from that in the theory of errors. In the theory of errors, the probability calculus had revealed order in chaos with the central limit theorem, and that discovery had made the measurement of uncertainty in aggregate measurements possible. In the social sciences the same magnificent theorem had posed a problem of seemingly incredible difficulty: How could the known diversity of causes be reconciled with this always present order? How could the normal distribution Quetelet had found be disassembled to allow a study of causes? Galton's quincunx had led to the answers to these question, by suggesting a new role for conditional probability. In the theory of errors, conditional probability had permitted inference about the constants of astronomers' theories. In regression analysis, conditional probability made possible the very definition of the quantities about which the statistician was interested in making inferences.

Looking back, we can see four distinctly different solutions to the problem of the combination of observations, four ways in which the variation in external factors could be allowed for in order to permit an attempt at aggregation: through external theory (as in astronomy); through experimental design (as in psychology); with internal regression analysis; and with large amounts of multiply classified data, through fine cross-classification. Actually, the last of these was not really feasible in the nineteenth century. When data were plentiful (for example, a census), it was in principle possi-

ble to look at all manner of categories; but in practice it was not. In regard to the U. S. census, Herman Hollerith wrote, "Until the census of 1890, we never even knew the proportion of our population that was single, married, and widowed . . . To have divided the native born into those of native parentage and those of foreign parentage, would have been practically impossible with the methods of 1880. To obtain the population classified according to age, sex, and birthplace of mother could not have been considered" (Hollerith, 1894, p. 678). This direct assault upon the de Keverberg dilemma would require modern tabulating equipment, even when the data were plentiful and at hand.

The conceptual triumphs of the nineteenth century had been the product of many minds working on many problems in many fields, and one of the most striking of their accomplishments was the creation of a new discipline. Before 1900 we see many scientists of different fields developing and using techniques we now recognize as belonging to modern statistics. After 1900 we begin to see identifiable statisticians developing such techniques into a unified logic of empirical science that goes far beyond its component parts. There was no sharp moment of birth; but with Pearson and Yule and the growing numbers of students in Pearson's laboratory, the infant discipline may be said to have arrived. And that infant was to find no shortage of challenges.

5. Esoteric research should provide exoteric hammers

My current research program, which I call Change Analysis in the wide sense, has among its goals the unification of parametric and nonparametric statistical methods for discrete and continuous data and the detection and measurement of change. Our basic goal is a framework which emphasizes the development of "analogies between analogies" (a concept created by von Neumann and Ulam to describe the next level of mathematical theory after "analogies between theorems").

I am excited by the "analogies between hammers" that can be developed between four fundamental distinct theories of statistical function smoothing:

1. Probability density estimation
2. Spectral density estimation
3. Nonparametric regression (fixed effect)
4. Nonparametric regression (random effect).

I would like to make a plea that (before the year 2000) the fundamental statistical hammers of function estimation should become *exoteric* (consumer products for applied statisticians) rather than *esoteric* (just an intellectual game of specialized smoothing statisticians). Even members of the esoteric group may not be aware of the latest recommendations for algorithms to compute kernel estimators.

The concepts of esoteric research yielding exoteric hammers (spinoffs) are intended to raise our consciousness about a research trend that often becomes apparent to senior scholars with many years experience: *the researchers in a field individually prosper doing research which adds to their reputation but the field as a whole is not prospering in the sense that it is not doing important things that have an impact outside of the field.* I believe that there is a remedy: researchers in the field should organize to do strategic planning, to act collectively to define the missions of the field and to ensure that things get done that (under the system of individual initiative) are alleged not to add to one's reputation.

Examples of how groups can aim to continuously improve the quality of their field: (1) stimulate expository review articles which call attention to methods which are the "best" hammers for applications and to important advice that were once published somewhere (and often are not given exoteric exposure because they are part of the folklore known to esoteric researchers); (2) raise consciousness about good taste in choice of research problems (which research problems are internally generated rather than externally generated, and which optimization criteria have scientific significance).

Modern British poets complained that modern mathematicians were better treated because clerks would write letters to newspapers complaining that they did not understand modern poetry but never complained about not understanding modern mathematics. The future of statistics (and of computational statistics) requires the statistical public be sufficiently concerned to write letters complaining that (1) esoteric statisticians should be more concerned to be exoteric by constructing statistical hammers more applicable to increasingly complex statistical nails, (2) applied statisticians should be more statistically cultured and more effectively use the continually improving statistical hammers available, and (3) computational statistical software packages should help achieve goals (1) and (2).

I believe that to succeed one has always needed (in addition to talent) a "hook" which promises an impact. Being an eternal optimist, I believe that the future is very promising for those mathematical, statistical, com-

putational scientists who are aware of both esoteric and exoteric goals.

6. Quality control of the art of statistical science

Question: Why do I propose that hammers and nails are useful concepts to describe respectively methods and applications in the discipline and profession of statistics?

Answer: They can aid statisticians' understanding (and public understanding) of past and future history of statistics, can help us communicate with the public, and can help provide control procedures to continuously improve the quality of the art of statistical science. The means by which statisticians can achieve these ends is to practice fun statistics that is elegant (award winning hammers) as well as useful (award winning nails).

Statisticians need to support each other with more awards. To improve their image (and avoid decline) statisticians must improve how their contributions are recognized and propagated by other researchers.

The future of the statistical sciences requires: improvements in hammers; improvement in abilities to transform problems to nails; and improvements in statistical history, culture, and communication. I hope I have stimulated your interest in discussing with your colleagues the question of how to improve the quality of the arts of statistical science and computational statistics.

In this talk on the history of statistics in real time it is very appropriate to pay tribute to the vision and initiative of the pioneers of the annual Interface symposia (begun in 1967 in Southern California by Arnold Goodman and Nancy Mann) and to those who created the Interface Foundation to perpetuate the vision and initiative. The tradition of great organizers has been maintained this year by Joe Newton (who is also my esteemed colleague and friend, Head of the Statistics Department at Texas A&M, and author of the important book TIMESLAB). Let's toast Joe!

I would like to conclude with a computational statistics variation of the statistical joke with which I began this talk.

One statistician to another: Colleague, I'd like to become a computational statistician; what are my chances?

Answer: If you don't know, you should attend the next Symposium on the Interface of Computer Science and Statistics.

Accession For	
NTIS GRA&I	☑
DTIC TAB	☐
Unannounced	☐
Justification	
By	
Distribution/	
Availability Codes	
Dist	Avail and/or Special
A-1	

DTIC QUALITY INSPECTED 8